**AUTONOMOUS ASTRONOMICAL OBSERVATORY TO CAPTURE AND ANALIZE METEOROID EMISSION ESPECTRA.** F. Espartero[1,2,3], G. Martínez[2], F. Pérez-Briceño[3], M. Frías[4]. [1]Area de Ciencia y Tecnología, International University of Valencia, Pintor Sorolla 21, 46002 Valencia (Spain). [2]Departamento de Ingeniería de la Construcción y Proyectos de Ingeniería, Campus de la Fuentenueva, University of Granada (Spain). [3]Observatorio Andaluz de Astronomía, 23680, Alcalá la Real, Jaén (Spain). [4]School of Physics, University of Bristol, BS8 1 TL Bristol, United Kingdom.

**Introduction:** We present a new astronomical observatory designed to study meteor spectra autonomously. Autonomous Observatory for Spectrography (AOS) is constituted by a small autonomous observatory, two spectrographs, a meteorological station and a computer. The Observatory is formed by a metal box of square section of 0.4 meters and 0.3 meters high, with a tilted roof divided into two equal parts, which can open and close the roof completely so that all-sky images can be taken. The opening / closing control of the observatory and the activation of the spectrographs to capture images is regulated through the PC and the meteorological station, which incorporates a Sky Quality Meter (sky brightness), an Anemometer (wind speed) and a Hygrometer (relative humidity)

All the devices that are part of this observatory have been programmed through the control computer so that autonomous captures of meteor images and their spectra are made every night and can be stored on the hard drives [1]. The AOS is in the Andalusian Observatory of Astronomy (37°24'54"N, 03º57'12" W) in Alcalá la Real (Spain).

**Instrumentation and methods:** The AOS spectrographs have different optical configurations and are equipped with monochrome CCD cameras and a holographic diffraction grating of 1000 lines / mm. Spectrograph #1 has an Atik 314 L + camera with a 1392 x 1040 pixel sensor and a Sigma 4.5 mm large field objective with an f/2.8 focal, which provides a field of view of 120°. Spectrograph #2 incorporates an Atik 11000 with a 4008 x 2672 pixel sensor and a 50 mm Nikon lens with f/1.2 that provides a field of view of 15°. Both spectrographs point to the zenith [1].

This set of devices constitutes an observatory designed for the study of meteor emission spectra [2] and its operation has been substantially improved, so that it can operate systematically in an easier and more efficient iterative mode (Figure 1). The AOS can thus capture images and store them on its hard disk when the sky brightness magnitude (mag / arcsec$^2$) is greater than 12 (night), the relative humidity (cloud index) is less than 70% and the wind speed does not exceed 40 km/s. This improvement also includes the implementation of a solar panel module with an auxiliary battery, which allows the observatory to have electric power in any location. The system supplies electricity at different voltages and allows the continuous operation of all equipment.

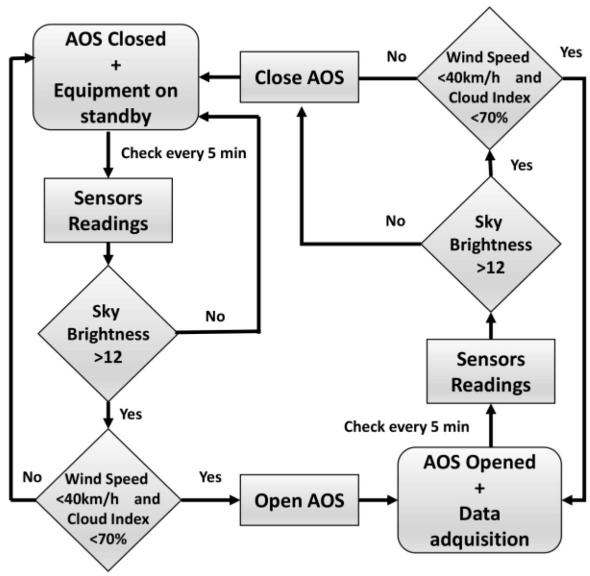


Figure 1. Flow diagram for data acquisition and operation of the observatory.

The captured images are reduced with MAXIM DL software and the spectra are analyzed with CHIMET software [3].

In order to determine the parent body of a meteorid, we need to have information on the object from at least two or more locations [4]. In this case we have additional images and video captures, from the Torcal Astronomical Observatory (36°57'10"N, 4º32'42"W) in Antequera (Spain) and the BOOTES-1 Observatory (37°06'15"N, 6º44'03"W) in Huelva (Spain). From these stations, full-sky images have been obtained, with an SBIG All Sky camera with a 1.4mm Fujinon lens that allows us to capture images with a 180ºx108º field and a 120mm ZWO video camera with a 1.4mm Fujinon lens and a field of 185ºx85º [5].

**Observations:** With the new configuration of the AOS a first fireball M20160727_022352, was captured on July 27, 2016 at 2 h, 23 m 52 s UT. The naming convention corresponds to M for meteor, followed by the date (year YYYY, month MM, day DD) and UT time (hour HH, minute MM and seconds SS). The image obtained from the meteor and its spectrum is shown in

Figure 2. Its apparent visual magnitude was approximately -9. It was captured by spectrograph #1 with a 75 second exposure. The effect of the Moon's brightness can be appreciated in the image.

Figure 2. M20160727_022352 fireball spectrum image obtained with spectrograph #1.

**Radiant and orbital data:** Since large field cameras are used to obtain the images, the air mass range was taken into account to calculate the extinction and determine the Bouger line. The V-band magnitudes of calibration stars taken from the Hipparcos catalog have been used. We have used the software developed by Aznar et al. (2016) [6] to obtain the centroids of the traces of the meteor.
The apparent radiant was located at $\alpha = 304.33$ °, $\delta = -8.12$ ° equatorial coordinates. The velocities in the brightness estimation have also been obtained. Their astrometric results are shown in table 1 and they relate the meteor to the Alpha-Capricornids meteor shower.

| **Vg (km/s)** | **e** | **a (AU)** | **i (°)** | **q (AU)** | **ω (°)** | **Ω (°)** |
|---|---|---|---|---|---|---|
| 22.35 | 0.75 | 2.39 | 6.95 | 0.58 | 269.9 | 124.5 |

Table 1. Orbital data (J2000) of the meteor M20160727_022352.

The emission spectrum obtained was analyzed with the CHIMET software (Figure 3) and shows the main emission lines corresponding to the Fe-43, Fe-41 and Fe-42 multiplets, together with the prominent lines of the Na-I doublet ( 5.889 Å) and the Mg I-2 triplet (5.167 Å) [7].

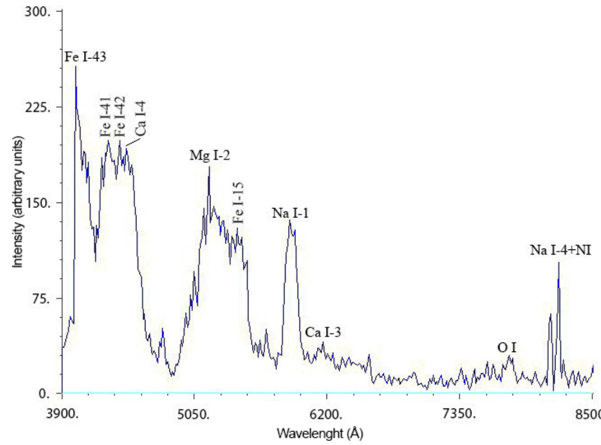


Figure 3. Calibrated emission spectrum of fireball M20160727_022352 in units of relative intensity as a function of wavelength (Å).

**Conclusions:** We have presented the modifications and advances made in the Autonomous Observatory for Spectrography (AOS), which allow us to obtain images of meteors and their spectra autonomously. The system has been designed to protect the set of equipment that operates inside automatically.
One of the first objects captured with spectrograph #1 has been analyzed. The emission spectrum of the meteoroid M20160727_022352 and its astrometric study from three stations has been resolved, which has made it possible to relate it to the Alpha-Capricornids meteor shower.

**References:** [1] Espartero F. et al. (2018), *Earth, Planets and Space*, 70, 02. [2] Espartero F. et al. (2018), RevMexAA, Conf. Ser., in press. [3] Madiedo J.M. et al. (2013) *MNRAS*, 433,571. [4] Ceplecha Z. (1987), Bull. Astron. Inst. Czechosl., 38, 222-234. [5] Borovička J. et al. (1995), A&A Sup. Ser., 112, 173. [6] Aznar, J.C. et al. (2016), RevMexAA, Conf. Ser., 48, 99-102. [7] Espartero, F. (2018), PhD Thesis, Complutense University of Madrid.